

RESEARCH PROJECT SEGMENT

State: Alaska

Project No.: F-9-4

Name: Sport Fish Investigations of Alaska.

Study No.: R-IV

Study Title: A Study of Dolly Varden in Alaska.

Job No.: R-IV-D

Job Title: Dissemination of Information
Collected on Dolly Varden.

Period Covered: July 1, 1971 to June 30, 1972.

ABSTRACT

This report presents the results of information collected at Hood Bay Creek, Southeast Alaska, from May, 1968, through May, 1971, on rearing Dolly Varden, Salvelinus malma, and coho salmon, Oncorhynchus kisutch. Study emphasis was placed on competition, food habits, and habitat requirements of rearing fish.

Rearing Dolly Varden and coho were distributed throughout Hood Bay Creek with young char appearing to prefer undercut banks as habitat and more coho distributed in sloughs, backwaters, and slow moving tributaries. Fry of both species were commonly found along stream margins and small tributaries.

Both species of rearing fish appear to move to the warmer headwater tributaries to overwinter. During the winter, fewer Dolly Varden were found feeding than coho.

Interspecific and intraspecific competition was observed in Dolly Varden-coho communities with coho fry and Dolly Varden fingerling being the most aggressive.

Dolly Varden and coho communities appear to be vertically segregated, with rearing char feeding closer to the substrate and coho feeding at the surface.

Rearing fish population densities were influenced more by intraspecific competition than interspecific competition.

The food habits of rearing fish appear to remain fairly constant during the rearing period.

Both species of fish utilize invertebrate drift for food, coho to a much greater extent than Dolly Varden.

Dolly Varden may feed selectively on Chironomidae larvae.

RECOMMENDATIONS

This information is intended to form a foundation for future studies on rearing fish in streams. Future investigations of rearing fish should include an examination of various population estimate techniques and methods for their application. Also, since a large amount of information remains to be published on Dolly Varden, this job should be continued.

OBJECTIVES

To write and publish information collected on anadromous Dolly Varden in Southeast Alaska.

INTRODUCTION

This report summarizes data collected on juvenile Dolly Varden and coho at Hood Bay Creek from May, 1968, through May, 1971. We hope to eventually formally publish this information; however, because little is known of the habits of young Dolly Varden, we felt the information collected should be presented as soon as possible in its entirety.

Our interpretation of these results should be regarded as preliminary and subject to change.

TECHNIQUES USED

Seasonal Distribution

Juvenile Dolly Varden and coho populations were sampled at Hood Bay Creek in March and April, 1971, using minnow traps baited with salmon eggs to determine the distribution of the fish at this time. Observations of ice cover and air and water temperatures were taken from November, 1970, to April, 1971. Catch results were compared to distribution information collected in the summer, 1969.

Habitat Preferences

Stream habitats were randomly sampled from tide water to the head waters with baited minnow traps. Ten types of habitat were classified and sampling results were grouped accordingly. Catch results were analyzed for catch and length frequency by habitat.

Aquarium Studies

Behavior experiments were conducted in a 40-gallon glass aquarium. The filtering apparatus was adjusted so that a continuous circular current was established. Five Dolly Varden and five coho, obtained from Hood Bay Creek with minnow traps, were introduced into the tank either together or alone and allowed to acclimate overnight before observations began. Notes on fish behavior were recorded on a tape recorder for 10-minute periods.

To determine reactions to the presence of food, insects and salmon eggs were introduced on the surface of the water with forceps or released in the middle and bottom of the tank with a glass tube.

Fry used in the experiments ranged from 34 - 46 mm and 30 - 47 mm for coho and Dolly Varden, respectively. Fingerling coho and Dolly Varden ranged from 74 - 84 mm and 78 - 92 mm, respectively. Water temperatures ranged from 52°-57°F during the test period.

Natural Observations

Observations of rearing fish under natural conditions were conducted in Hood Bay Creek. Areas with good visibility were selected so that fish could be watched easily. Areas were approached carefully so that fish were not disturbed, and after the fish appeared settled, 10-minute observations were conducted on behavior and feeding habits. Water temperature in the observation areas ranged from 45° - 48°F. The fry were estimated to be from 43 - 65 mm and 30 - 55 mm in length, respectively, for coho and Dolly Varden. Coho and Dolly Varden fingerling were estimated to be from 46 - 76 mm and 51 - 100 mm, respectively.

Trough Experiments

Four wooden troughs, similar to those used by Chapman (1962) were constructed at Fall's Creek in Hood Bay. Two of the troughs were used for a control and two for experimental stream channels. Twelve fish, six Dolly Varden, and six coho were placed in each experimental trough, and six of either species were introduced to the two control troughs. The fish of each experiment were chosen for their similar size to eliminate size-related factors of competition, and usually ranged from 50 - 85 mm in length. Displaced fish were caught in a trap at the end of each trough and were either returned to the trough or replaced with new fish of

similar size. The troughs were covered with heavy gauge hardware cloth to prevent predators from entering. Also, the type of substrate was changed from fine gravel to varying amounts of large gravel and rocks to determine the effects of substrate type.

Insect Investigations

A total of 83 samples were taken with a square foot Surber sampler in Hood Bay Creek. Specimens from each sample were sorted by hand, preserved in 70% ethyl alcohol and identified to species if possible. All determinations were made from immature forms except Isogenus nonus Banks, as adult specimens have not been collected or reared for other species.

Familiarization with insect species collected by Surber sampler enabled us to determine the quantities of each species consumed by rearing Dolly Varden and coho.

Gut Analysis

Fish were examined for stomach contents by removing that portion of the stomach from the end of the esophagus to the pylorus. The stomach was then slit open and the contents teased out, identified, and counted.

For the purposes of this study, each food item in the stomach samples was assumed to represent a single feeding sortee. The sum of all the individual feeding movements could therefore be regarded as the generalized feeding behavior. Thus, food items were counted instead of being weighed and measured volumetrically.

Allochthonous-Autochthonous Ratios

The frequency of feeding on subsurface (Autochthonous) foods relative to surface foods (Allochthonous) was obtained with the expression:

$$C = \frac{\text{No. Allochthonous items}}{\text{No. Autochthonous items}}$$

When: $C = 1$, equal numbers of allochthonous and autochthonous food items were consumed.

$C < 1$, more food items were consumed below the surface (Autochthonous).

$C > 1$, more food items were consumed on or above the surface (Allochthonous).

FINDINGS

These findings are the results of data collected on juvenile Dolly Varden, Salvelinus malma, and coho, Oncorhynchus kisutch, from May, 1968, through May, 1971. Additional information on juvenile Dolly Varden and coho in South-east Alaska may be found in Armstrong (1963, 1967, 1970); Armstrong and Kissner (1969); Armstrong and Morton (1969); Armstrong and Winslow (1968); Blackett (1968); Heiser (1966).

Seasonal Distribution

Blackett (1968) found a distribution of young Dolly Varden in Hood Bay Creek during July, August, and September which indicated an overall usage of the freshwater habitat above the intertidal zone. He also observed small schools of Dolly Varden young swimming in midstream during October. This schooling of young fish had not been observed before and he assumed that some type of movement was in progress. Sampling throughout the entire creek in November indicated that the majority of the rearing Dolly Varden were located in the upstream areas. Blackett (1968) concluded that there was an upstream movement of rearing Dolly Varden in the fall.

Sampling to determine the distribution of coho and Dolly Varden young in Hood Bay Creek during March and April, 1971, indicated a greater concentration of these fish in the uppermost portion of the creek (Table 1). We believe that many of the rearing fish move upstream in late fall, remain in the uppermost portions of the creek during the winter and spring and redistribute themselves throughout the rest of the creek in early summer.

TABLE 1 Catch Per Trap of Coho and Dolly Varden Young in Hood Bay Creek by Section and Month.

Section	Coho			Dolly Varden		
	August	March	April	August	March	April
1	10.9	14.7	17.7	42.8	1.9	5.1
2	6.0	5.3	3.0	72.6	1.2	2.1
3	12.8	4.0	2.7	50.9	0.3	1.1
4	15.8	1.1	0.0	48.2	0.3	0.0
5	14.8	4.9	2.4	35.5	0.3	2.0
6	29.5	8.5	8.2	9.3	0.4	0.0

A warmer water temperature in the uppermost section of Hood Bay Creek may be the major reason for a movement of fish into this area for the winter. Temperatures taken during November and December of 1970 indicated that most of section 1 remained at 41° - 43°F while the rest of the creek was 31° - 34°F (Table 2). During December the water throughout section 1 remained icefree while the remainder of the creek had a layer of approximately six inches of ice, with the exception of the shallow riffle areas which remained open.

TABLE 2 Comparison of Water Temperature (°F) in Section 1 of Hood Bay Creek to the Rest of the Creek.

<u>Date</u>	<u>Section 1</u>	<u>Rest of Creek*</u>	<u>Air Temp.</u>
11/25/70	41-43 (12)**	34	14
12/ 1/70	41-43 (6)	33	11
12/ 2/70	41-43 (12)	32	3
12/ 3/70	41-43 (4)	31	1
12/ 4/70	41-43 (12)	31	-3
3/11/71	41-43 (12)	39	35
3/16/71	41-43 (12)	39	34
3/25/71	41-43 (12)	39	34

*Average of a series of random observations throughout the creek.

**Number of areas sampled for temperature.

Habitat Preferences

The trap catches of Dolly Varden and coho in the different habitats indicated a usage of all habitat types of both species (Table 3). More Dolly Varden young than coho young were caught in each of the 10 different habitats. The number of Dolly Varden caught per trap was highest in the undercut bank areas along the mainstream and side channels. The number of coho caught per trap was highest in sloughs and undercut bank areas along side channels.

The largest Dolly Varden were caught in riffle areas and the smallest were caught in sloughs and isolated pools (Table 4). There were no obvious differences in size of coho caught by habitat type (Table 5). However, the data does suggest that smaller coho were caught in habitats with a slower water velocity.

More of the traps caught both species rather than only one species. Of the 375 traps set, 245 (65%) caught a mixture of coho and Dolly Varden, 105 (28%) caught only Dolly Varden, and 25 (7%) caught only coho. This would indicate that the two species are at least residing in close enough proximity to each other to be attracted to the same food source.

TABLE 3 Percentage and Catch Per Trap of Dolly Varden and Coho Caught by Minnow Trap in Each Habitat Type in Hood Bay Creek during July and August.

	No. of Fish	% Caught		Catch/Trap		No. of Traps
		DV	Coho	DV	Coho	
FSR	522	85	15	12	2	37
SSR	704	88	12	20	3	31
FOR	624	83	17	25	5	21
SOR	251	83	17	13	3	16
OP	1,020	88	12	16	2	55
SP	2,699	77	23	22	6	95
IP	372	72	28	14	5	19
MU	1,310	87	13	31	4	37
SU	1,603	72	28	32	12	36
S	<u>1,053</u>	<u>61</u>	<u>39</u>	<u>23</u>	<u>15</u>	<u>28</u>
Total	10,158	79	21	21	6	375
FSR - Fast sheltered riffle						
SSR - Slow sheltered riffle						
FOR - Fast open riffle						
SOR - Slow open riffle						
OP - Open pool						
SP - Sheltered pool						
IP - Isolated pool						
MU - Mainstream undercut bank						
SU - Side channel undercut bank						
S - Slough						

Observations of the distribution of coho and Dolly Varden fry and fingerling in Hood Bay Creek indicated the fry utilized the shallow stream margins and small shallow tributaries and the fingerling were in the deeper water areas. Very small rivulets of 1/2- to 1-inch in depth and only a few inches across often contained numerous Dolly Varden fry in early summer.

TABLE 4 Length Frequency of Dolly Varden Young Caught by Minnow Traps in Different Habitats in Hood Bay Creek During July and August.

Length Range (mm)	Riffle Areas				Pools			Undercut Banks		Slough	Total
	<u>FSR</u>	<u>SSR</u>	<u>FOR</u>	<u>SOR</u>	<u>OP</u>	<u>SP</u>	<u>IP</u>	<u>MU</u>	<u>SU</u>	<u>S</u>	
41 - 50	0	0	0	0	3	1	5	0	9	5	23
51 - 60	13	34	7	10	46	174	77	69	152	150	732
61 - 70	79	111	70	28	172	434	78	202	323	190	1,687
71 - 80	92	111	93	26	169	419	49	200	228	132	1,519
81 - 90	66	113	130	20	186	455	36	272	200	80	1,558
91 - 100	70	128	85	46	155	316	10	176	130	51	1,167
101 - 110	60	59	82	46	114	155	6	125	66	21	734
111 - 120	40	46	34	18	33	93	4	65	41	6	380
121 - 130	20	14	15	10	13	26	3	30	6	4	141
131 - 140	3	5	4	3	8	6	0	4	3	0	36
141 - 150	<u>0</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>0</u>	<u>2</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>8</u>
Total	443	622	521	208	899	2,081	268	1,143	1,159	641	7,985
\bar{x} Length	87.1	84.9	88.0	91.3	83.5	80.8	69.2	84.1	76.4	71.3	81.2

TABLE 5 Length Frequency of Coho Young Caught by Minnow Traps in Different Habitats in Hood Bay Creek During July and August.

Length Range (mm)	Riffle Areas				Pools			Undercut Banks		Slough	Total
	<u>FSR</u>	<u>SSR</u>	<u>FOR</u>	<u>SOR</u>	<u>OP</u>	<u>SP</u>	<u>IP</u>	<u>MU</u>	<u>SU</u>	<u>S</u>	
31 - 40	0	0	0	0	0	2	0	0	1	5	8
41 - 50	6	13	6	18	11	67	20	22	80	91	335
51 - 60	15	24	24	8	20	138	22	37	150	113	551
61 - 70	26	19	29	10	41	172	36	39	100	96	568
71 - 80	21	16	23	6	36	169	23	40	82	74	490
81 - 90	9	8	17	1	13	57	3	23	26	28	185
91 - 100	2	1	3	0	0	10	0	5	5	5	31
101 - 110	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>3</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>5</u>
Total	79	82	103	43	121	618	104	167	444	412	2,173
\bar{x} Length	66.8	62.4	67.8	56.1	66.1	65.3	61.3	65.9	60.8	60.6	63.2

Behavior

Aggression:

In mixed communities of fry, no incidence of a Dolly Varden attacking a coho was recorded although several attacks on Dolly Varden by coho were noted. The opposite was observed in mixed communities of fingerling. Only one incidence of a coho attacking a Dolly Varden was recorded, whereas several incidences of Dolly Varden attacking coho were noted. The number of attacks observed during the aquarium and natural observations are presented in Table 6.

TABLE 6 Number of Attacks Made by One Species on Another During 100 Minutes of Observation of Each Species as Fry and Fingerling in Hood Bay Creek and in an Aquarium.

	<u>Fry</u>		<u>Fingerling</u>	
	<u>Natural</u>	<u>Aquarium</u>	<u>Natural</u>	<u>Aquarium</u>
DV to Coho	0	0	20	4
Coho to DV	6	11	1	0
DV to DV	3	3	2	11
Coho to Coho	30	20	17	2

When by themselves in an aquarium, the following number of attacks were recorded during 100 minutes of observation: Dolly Varden fry = 20; Dolly Varden fingerling = 0; coho fry = 55; coho fingerling = 26.

After a series of observations in the aquarium on a group of five Dolly Varden fingerling, where no incidence of aggression was noted, five coho fingerling of a size similar to the Dolly Varden were introduced. Within an hour after introduction of the coho, two of the Dolly Varden fingerling began attacking the other Dolly Varden, the coho, and each other. No aggression of coho toward Dolly Varden was noted.

During the observations of fry in Hood Bay Creek, some general behavior patterns were noted. The Dolly Varden fry were frequently observed moving near the stream bottom for several meters, often poking under rocks apparently in search

of food. The Dolly Varden fry did not appear to have obvious territories. In contrast, coho fry appeared to occupy specific stations and territories which they defended from other fry. On occasion, Dolly Varden fry were observed entering the territory of a coho fry which usually resulted in the Dolly Varden fry being chased by the coho sometimes for distances of up to two meters. Dominance over a group of fry by one of the fry during either the natural or aquarium observations was not noted.

In mixed communities of Dolly Varden and coho fingerling, a Dolly Varden was the despot in all of the observations. The Dolly Varden despot would have the largest territory usually at the head of a pool (natural observations) or toward the filter in the aquarium. The despot would attack any other fingerling entering its territory and appeared to defend the whole water column even though he was frequently resting on or swimming near the bottom. Occasionally the despot would swim throughout the aquarium or pool and attack other fingerling encountered.

Usually the despot Dolly Varden was one of the larger, but not necessarily the largest, fish in the pool area under observation.

Establishment of territories by other fingerling during either the aquarium or natural observations were not obvious. However, occasionally a second Dolly Varden fingerling would establish a much smaller territory than the despot. We suspect, however, that the other fingerling did establish territories but that the territory of the Dolly Varden despot was so obvious that it tended to bias our opinions as to the territories of other fish, which may have been more subtle.

Trough Experiments:

Twelve fish, six Dolly Varden and six coho, were placed together in troughs while six of either species were placed in an adjacent trough as a control. Twenty-one trials using coho as a control, and 23 trials using Dolly Varden as a control were conducted.

The results are expressed as the total number of fish leaving the troughs and are as follows:

	Experimental		Control
	Trough #1		Trough #2
	<u>DV</u>	<u>Coho</u>	<u>Coho</u>
No. Introduced	126	126	126
No. Leaving Trough	64	28	38
% Leaving Trough	50.7	22.2	30.1

	Experimental Trough #1		Control Trough #2
	<u>Coho</u>	<u>DV</u>	<u>DV</u>
No. Introduced	138	138	138
No. Leaving Trough	37	60	58
% Leaving Trough	26.8	43.4	42.0

Food Sampling:

Dolly Varden fry and fingerling were recorded sampling food from the stream bottom more frequently than at the surface. The opposite was observed for coho fry and fingerling which sampled food more frequently from the stream surface than at the bottom. The incidence of food sampling by the fry and fingerling is presented in Table 7.

TABLE 7 Incidence of Food Sampling by Dolly Varden and Coho Fry and Fingerling at the Water Surface and Stream Bottom During Observations in Hood Bay Creek.

	Fry		Fingerling	
	<u>DV</u>	<u>Coho</u>	<u>DV</u>	<u>Coho</u>
Surface	15	71	10	30
Bottom	76	27	92	15
Other	<u>94</u>	<u>14</u>	<u>11</u>	<u>8</u>
Total	94	112	113	53
Observation Time:	100 min.	100 min.	100 min.	100 min.

Food Introductions:

Food introduced into an aquarium containing five Dolly Varden and five coho fingerling was obtained by coho more often than Dolly Varden. The results of 40 food introductions of food at the surface and 40 food introductions at the bottom of the tank were:

	<u>Surface</u>	<u>Bottom</u>
Dolly Varden	10	17
Coho	30	23

Usually both species of fingerling raced for the food. Coho appeared to be faster swimmers than Dolly Varden and often reached the food first. Dolly Varden were more proficient at taking food introduced at the bottom than at the surface of the aquarium.

Vertical Distribution:

Dolly Varden young spent most of their time on or near the stream bottom during the observations of these fish in Hood Bay Creek. Dolly Varden fry were recorded resting on the bottom for 55% of the time and Dolly Varden fingerling rested 17% of the time on the stream substrate. In contrast, coho fry and fingerling were never observed in a resting position on the stream substrate.

Vertical distribution in the aquarium of fry and fingerling of both species, when mixed and alone, is presented in Tables 8 and 9. This information indicates that the presence of one species affects the vertical distribution of the other. Dolly Varden fry and fingerling spent more time resting on the bottom when coho were present than when alone. Dolly Varden fry spent more time in the upper half of the aquarium when they were alone.

TABLE 8 Vertical Distribution of Dolly Varden and Coho Fry in an Aquarium when Mixed and Alone.

	Dolly Varden		Coho	
	Mixed	Alone	Mixed	Alone
Upper Half	12%	26%	54%	25%
Lower Half	88%	74%	46%	75%
Bottom	63%	48%	0%	0%
Observation Time:	100 min.	100 min.	100 min.	100 min.

TABLE 9 Vertical Distribution of Dolly Varden and Coho Fingerling in an Aquarium when Mixed and Alone.

	Dolly Varden		Coho	
	Mixed	Alone	Mixed	Alone
Upper Half	2%	1%	13%	8%
Lower Half	98%	99%	87%	92%
Bottom	63%	38%	0%	0%
Observation Time:	100 min.	100 min.	100 min.	100 min.

General Food Habits

Juvenile Dolly Varden and coho utilize three major types of food during their stay in freshwater streams. Insects, both aquatic and terrestrial, are preyed upon by both rearing species throughout the year. Eggs and fry of pink and chum salmon are also consumed by Dolly Varden and coho during certain periods of the season when they are available to fish.

Dolly Varden stomach samples taken from April to June, 1968, showed that 177 rearing char consumed 49 salmon fry, an average of 0.28 fry per fish, and 175 juvenile coho ate 37 salmon fry during the same period, an average of 0.21 fry per fish. Salmon fry composed 1.4 - 20.4% of the diet of the Dolly Varden sampled during the fry emergence and emigration period. Fry composed 1.3 - 3.0% of the coho diet at this time (Table 10).

Salmon eggs formed 27.3 - 83.1% of 116 juvenile Dolly Varden sampled from July to October, 1968. The young char of this sample group consumed an average of 2.3 eggs per fish. The 112 juvenile coho sampled fed on 112 salmon eggs. Coho consumed an average of one egg each with 5.5 - 31.8% of the July to October diet being composed of salmon eggs.

The seasonal occurrence of salmon eggs and fry as food and its effect on the composition of the rearing fish diet is shown in Figure 1. We found that juvenile Dolly Varden and coho seldom fed on small fry of their own or other species. Of 594 rearing Dolly Varden and coho sampled from April to November, 1968, only six individuals contained smaller members of their own or the other rearing species.

Winter Food Habits

Samples were taken during March and April 1971, in the main stream and upper drainage of Hood Bay Creek. Essentially March and April are still winter months since the main stream is still covered with ice. The ice cover usually melts in May. The topography of the upper basin of Hood Bay Creek is typically bowl-shaped and contains numerous spring-fed creeks which join to form the head-water tributaries of the system. These springs and their outlet creeks are characterized by water temperatures that remain fairly constant throughout the year and appear never to freeze during the winter, even though air temperatures are often below zero. Forty percent of the 40 young Dolly Varden sampled from the upwelling areas had not fed, while only 14.6% of the 41 coho sampled at this time had empty stomachs. Stomach analysis during the summers at Hood Bay showed that the percentage of non-feeding char ranged from 9.3 - 14.8% of those sampled. Only 8.3 - 10.8% of the coho sampled during the summers had not fed. The young char showed a threefold decrease in the average number of organisms consumed, compared to feeding rates during the summer, while coho showed an average decrease of one.

TABLE 10 Percent Composition of Major Food Types Eaten by Rearing Dolly Varden and Coho at Hood Bay Creek, 1968.

	Dolly Varden				Coho			
	<u>Insects</u>	<u>Eggs</u>	<u>Fry</u>	<u>No. Sampled</u>	<u>Insects</u>	<u>Eggs</u>	<u>Fry</u>	<u>No. Sampled</u>
April	79.6		20.4	30	97.4		2.6	47
May	88.9		11.1	62	97.0		3.0	80
June	98.6		1.4	79	98.7		1.3	48
July	72.7	27.3		30	94.5	5.5		30
August	18.7	81.3		30	77.0	23.0		30
September	15.8	83.3		31	68.2	31.8		27
October	97.6		2.4	25	83.8	16.2		25
November	100.0			<u>10</u>	100.0			<u>10</u>
Total No. Fish				297				297

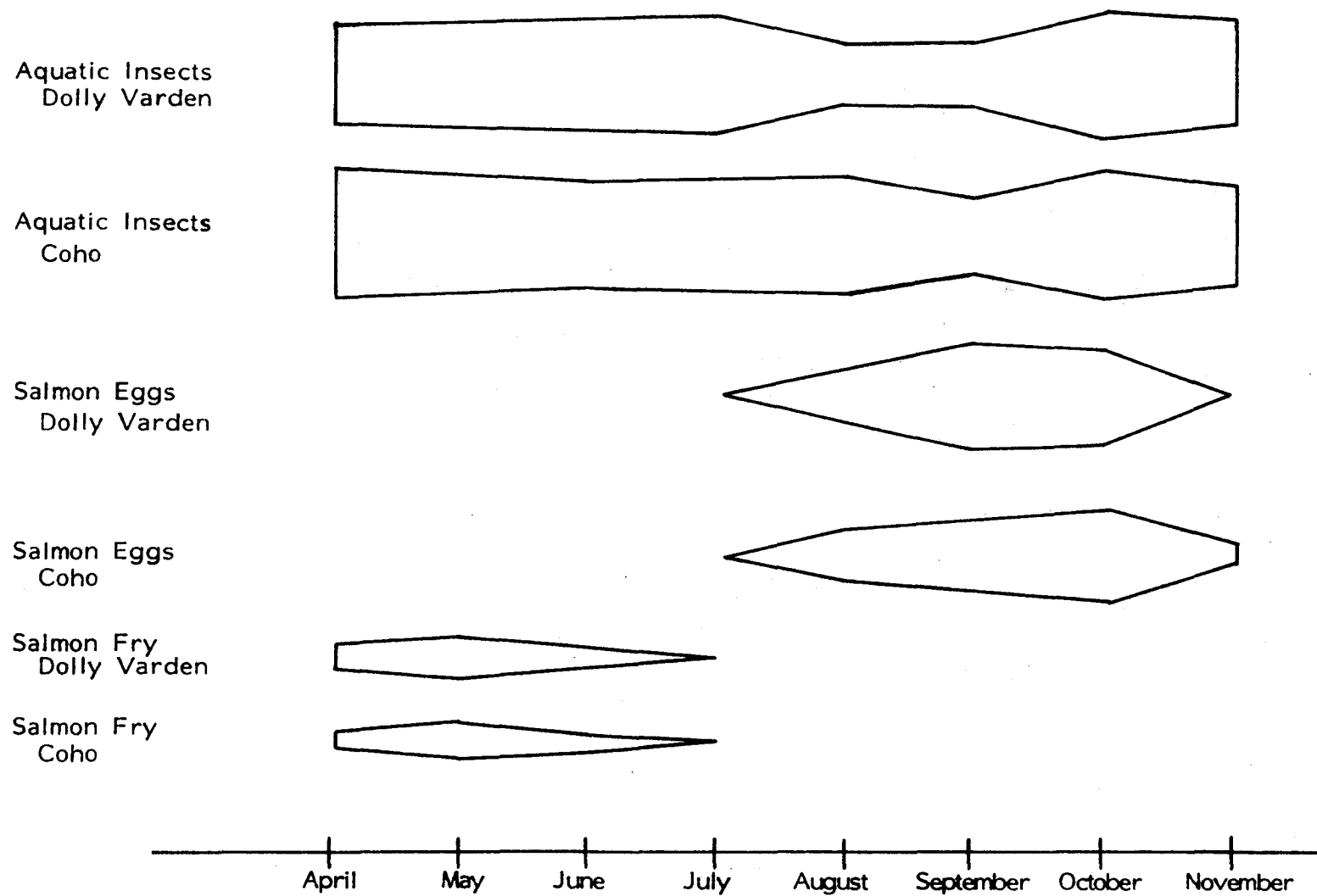


FIGURE 1 SEASONAL OCCURRENCE (%) OF THREE MAJOR FOOD TYPES IN HOOK BAY CREEK REARING FISH, 1968.

The Insect Fauna of Hood Bay Creek

The bulk of the benthic insect fauna at Hood Bay Creek was composed of the orders Ephemeroptera and Diptera (Tables 11 and 12). Mayfly nymphs comprised over 50% of the insect standing crop while Diptera made up 23.3%.

TABLE 11 Insects of Hood Bay Creek, Summer, 1969. Standing Crop and Percent Composition.

	<u>Insects Collected</u>		<u>Standing Crop (No./Sq. Ft.)</u>
	<u>No.</u>	<u>%</u>	
Ephemeroptera	1,147	50.86	13.81
Plecoptera	342	15.17	4.21
Trichoptera	242	10.73	2.91
Diptera	<u>524</u>	<u>23.24</u>	<u>6.31</u>
Total	2,255	100.00	27.24

No. of Samples = 83

TABLE 12 Relative Abundance of the Most Common Aquatic Insects of Hood Bay Creek, 1969.

	<u>% Within Order</u>	<u>% Composition in Fauna</u>	<u>Standing Crop (No./Sq. Ft.)</u>
Ephemeroptera			
<u>Cinygmula</u> sp.	60.1	30.95	8.3
<u>Baetis bicaudatus</u>	33.2	16.84	4.6
Others	6.7	3.07	0.9
Plecoptera			
<u>Alloperla</u> sp.	57.6	10.17	2.3
Others (<u>Capnia</u> sp., <u>Leuctra</u> sp.)	42.4	5.00	1.9
Trichoptera			
<u>Limnephilus</u> spp.	95.8	8.33	2.8
Others	4.2	2.40	0.1
Diptera			
Chironomidae	95.4	22.17	6.0
Others	4.6	1.07	0.3

No. of Samples = 83

Nine species of mayflies were identified, of which Cinygmula sp. was by far the most abundant, forming 30.6% of the total insect standing crop. Baetis bicaudatus was also prevalent, forming 16.8%.

The dipterous fauna was dominated by the family Chironomidae. The 11 species of chironomids identified at Hood Bay Creek formed approximately 22.0% of the total insect standing crop in 1969 with other dipterous species forming 1.0%.

Plecoptera nymphs composed 15.2% of the total insect standing crop with Alloperla sp. being the most abundant stonefly (10.2%). The order Trichoptera formed 10.7% of the standing crop and was primarily represented by Limnephilus spp. (3+ species). Limnephilus spp. composed of 8.3% of the total insect standing crop in 1969.

Cinygmula sp. and Baetis bicaudatus existed in most areas of the stream and were most abundant in substrate of large gravel (50 - 200 mm).

Members of the family Chironomidae inhabited the entire length of the stream from the upper intertidal areas (Chironomus sp.) to the headwaters of the creek (Diamesa sp., Orthocladius sp.).

The species of Limnephilus occurred throughout the length of the stream. One of the species (ca. 10 mm long) built cases from fine sand and occurred in high densities of up to 50 per square foot along the margin of streams. Other species (ca. 30 mm long) built cases from large gravel and vegetable materials and appeared to be restricted to back water eddies and deep pools where the water velocity was low.

Plecoptera nymphs, represented mostly by Alloperla sp. and Capnia sp., were common throughout the system and were usually found in the swifter riffle areas.

The species mentioned above, probably because they are the most abundant of the Hood Bay aquatic insect fauna, and because of their wide distribution in the stream, formed the bulk of the subsurface diet taken by rearing Dolly Varden and coho.

The Insect Diet of Dolly Varden and Coho

Both Dolly Varden and coho young at Hood Bay Creek consumed the same insect species but to a different extent.

TABLE 13 Contribution of Surface Insects from Various Habitats to the Diet of Sympatric Juvenile Coho and Dolly Varden at Hood Bay Creek, 1969. (Expressed as a percent; the number eaten is enclosed in parentheses.)

	<u>Slough</u>	<u>Stream Margin</u>	<u>Shaded Pool</u>	<u>Fast Riffle</u>	<u>Slow Riffle</u>	<u>Open Pool</u>
Dolly Varden (N=122)						
No. fish sampled	11	28	22	29	22	10
Subsurface foods	94.2% (26)	93.7% (102)	96.6% (169)	96.4% (182)	95.1% (171)	98.4% (16)
Aquatic insects	5.8% (1)	4.5% (5)	1.7% (3)	3.1% (6)	3.8% (7)	0.8% (1)
Terrestrial insects	0	1.8% (2)	1.7% (3)	0.5% (1)	1.1% (2)	0.8% (1)
A/A ratio	0.063	0.069	0.036	0.038	0.053	0.125
Coho (N=49)						
No. fish sampled	13	9	10	7	2	8
Subsurface foods	26.0% (29)	32.8% (18)	56.8% (66)	80.7% (37)	81.9% (9)	79.6% (105)
Aquatic adults	4.4% (5)	25.4% (14)	13.4% (18)	2.9% (14)	18.1% (2)	13.6% (6)
Terrestrial insects	69.6% (78)	41.8% (23)	29.8% (40)	16.4% (10)	0	6.8% (3)
A/A ratio	2.862	2.056	0.879	0.649	0.222	0.086

Both young salmonids fed upon approximately equal amounts of Cinygmula sp., Baetis bicaudatus, and Alloperla sp. Young Dolly Varden fed on more Limnephilus spp. larvae (ca. 10 mm) and Chironomidae larvae (mostly Orthocladius sp. and Polypedilum sp.) than did coho young. Conversely, the largest portion of the coho diet was composed of surface insects (Table 13).

Allochthonous-autochthonous ratios show that coho young consistently fed more on the surface than did Dolly Varden during the years sampled.

	<u>August, 1969</u>	<u>August, 1970</u>	<u>Spring, 1971</u>
Dolly Varden (N=306)	0.36	0.39	0.02
Coho (N=197)	1.13	2.59	0.16

The 1971 sample was taken in March and April when the snow was still several feet deep and terrestrial insect activity was low. Most of the surface insects consumed in this period were aquatic adults.

Large quantities of surface food items in the guts of coho young suggests that they spend more time feeding near the water surface. Dolly Varden appear to spend more time feeding closer to the substrate.

Observations of feeding fish also appear to be significant, Dolly Varden were observed alone in a small pool along the stream margin. They were feeding on small organisms on the substrate. Occasionally, one would rise to feed on items drifting on the surface, but this occurred only rarely. When alone, coho young appeared to concentrate their feeding activity near the water surface, usually maintaining a position about 4 - 6 inches beneath the surface. They consistently rose to the surface to collect small food items. Some coho were cruising near the substrate which contained up to 100 small Limnephilus larvae about 10 mm long actively crawling over the rubble. Occasionally, a coho would swim up to a larva, appear to examine it, then swim away without any attempt to feed.

Both species of fish appeared to utilize drifting insects and were observed to feed, while together, on drifting items in the middle of the water column. Table 14 suggests that both Dolly Varden and coho feed on approximate amounts of Baetis bicaudatus and Cinygmula sp. Both of these insects are thought to be abundant in the drift at Hood Bay Creek, but no study was conducted to ascertain their role in the drift biota.

Change in Diet During the Rearing Period

No significant change in diet was observed for either Dolly Varden or coho young as growth was attained. However, it was noted that the smaller Dolly

TABLE 14 Percent Consumption of the Seven Most Common Insect Species and Groups at Hood Bay Creek, August, 1969, August, 1970, and Spring, 1971.

	Dolly Varden			Coho		
	1969	1970	1971	1969	1970	1971
No. fish examined	156	110	40	63	93	41
<u>Baetis bicaudatus</u>	7.16	5.14	7.22	5.80	3.33	19.00
<u>Cinygmula</u> sp.	13.76	14.57	13.30	8.07	11.30	20.00
<u>Alloperla</u> sp.	1.93	1.56	2.40	1.66	2.31	3.00
<u>Limnephilus</u> spp.	16.62	14.72	7.22	5.65	2.31	10.50
Chironomidae	45.96	49.90	59.05	14.01	34.50	26.00
Other aquatic spp.*	6.02	3.11	8.41	4.01	2.92	2.00
Surface insects**	<u>3.55</u>	<u>10.72</u>	<u>2.40</u>	<u>60.80</u>	<u>43.33</u>	<u>19.50</u>
	100.00	100.00	100.00	100.00	100.00	100.00

Total Fish Examined: Dolly Varden = 306
Coho = 197

*Other aquatic species: includes Ameletus sp., Epeorus sp., Paraleptophlebia sp., Isogenus sp., Rhyacophila sp., Dicranota sp., Palpomyia sp., Prosimulium sp., and Atherix sp.

**Surface insects: includes both adult aquatic species and all insects of terrestrial origin.

Varden or coho tended to consume smaller organisms such as chironomid larvae, and that larger individuals were capable of feeding on insects such as Limnephilus sp. (ca 30 mm long) and larger Ephemerella nymphs (20 mm long). Allochthonous-autochthonous ratios for different size classes of Dolly Varden and coho young (Table 15) appear to indicate that the same general food habits are consistent throughout the rearing period for both salmonid species and that no radical change in feeding habits occurs during growth.

TABLE 15 Size of Rearing Dolly Varden and Coho Related to Allochthonous-Autochthonous Ratios, Hood Bay Creek, 1970.

Length (mm)	Dolly Varden		Coho	
	Alloc/Autoc	No. Samp.	Alloc/Autoc	No. Samp.
30 - 40	--	-	3.08	6
41 - 50	0.79	2	3.40	34
51 - 60	0.42	20	2.93	26
61 - 70	0.32	29	1.64	21
71 - 80	0.30	30	4.95	6
81 - 90	0.21	13	--	-
91 - 100	0.32	8	--	-
101 - 110	2.89	4	--	-
111 - 120	0.53	4	--	-

Terrestrial Insects

Gut analysis of young Dolly Varden and coho in 1969 from six specific habitat types showed that consumption of terrestrial and aquatic adult insects varied with the sampled habitat.

Allochthonous-autochthonous ratios and percent composition (Table 15) indicate that both Dolly Varden generally consumed more surface insects in sloughs, stream margins, and shaded pools than they did in other habitats. Also, juvenile coho consumed more terrestrial insects in these three habitats.

The slough, stream margin, and shaded pool habitats had two things in common: all had vegetation closely bordering or overhanging the sites, and all had relatively low current velocity. Many species of terrestrial insects, especially small parasitic Ichneumonidae (Hymenoptera), appeared to be associated with streamside alder growth. Also, the alders served as a resting site for adult aquatic forms. Due to the lower current velocity, aerial insects falling from marginal vegetation, become immediately available to waiting fish.

The contribution of aerial insects from vegetation is probably of great significance. Due to low current velocities, insect drift may be minimal and without food from terrestrial sources, the carrying capacity for juvenile Dolly Varden and coho could be reduced considerably.

Evidence of Drift Feeding

Many authors have shown that juvenile coho in streams rely on drift insects for a major portion of their diet. Little work has been done on the utilization of drift food by young Dolly Varden. No drift samples were taken from Hood Bay Creek to determine the quantity of drift; consequently, no direct correlation can be drawn between drift and the food composition in char gut samples.

Nilsson (1957) states that chironomid pupae, trichoptera pupae and terrestrial insects are obligate drift organisms. Stomach samples taken in 1971 from rearing Dolly Varden and coho showed that 27% of the food consumed by 41 coho was composed of chironomid pupae and insect exuviae. Surface insects composed from 19.5 - 60.8% of the juvenile coho sampled over three seasons. The Dolly Varden diet was composed of 3.6% pupae and exuviae in 1971, and from 2.4 - 10.1% surface insects during the years sampled.

Waters (1962) reported that Glossosoma intermedium (Klapalek) (Trichoptera: Glossosomatidae) drifted at a rate of 350 per hour per foot and that all were lacking their stone cases. Stomach samples of coho young at Hood Bay Creek in 1969 showed that 42.8% of the Trichoptera larvae (mostly a small limnephilid about 10 mm maximum length) consumed were lacking their stone cases. We also found that 28.6% of the small Limnephilidae larvae consumed by rearing Dolly Varden were without their cases. There was no evidence to show that the cases had been digested, as there were never any copious amounts of sand in the stomachs. In fact, it was noted that in general, the small Limnephilidae larvae were usually digested inside the case, and though the cases usually lost some of their rigidity, they were never completely digested. Cases found at the extreme end of the intestine still retained their structural integrity.

We suggest that most of these larvae had abandoned their cases for some reason and were swept downstream by the current, thereby entering the drift. Dr. Stamford D. Smith (personal communication) feels that the caseless larvae found in the guts of the rearing fish, were probably derived from the drift.

To what extent drifting Ephemeroptera are utilized by the rearing species is not known. Drift rates have been established for Baetis bicaudatus and Cinygmula sp. (Brusven, 1970) and for Baetis sp. by many other authors. Cinygmula and B. bicaudatus, which occur in high densities in Hood Bay Creek, probably form a substantial portion of the drift. Undoubtedly they form a major part of the drift food consumed by coho and Dolly Varden.

The data suggests that coho consume a great deal of drift food derived from the surface and water column, while Dolly Varden appear to feed closer to the bottom and occasionally sample from the drift in the water column.

DISCUSSION

Many authors have shown that juvenile salmonids exhibit some type of movement in streams during the fall or winter. Chapman and Bjornn (1969) have shown that juvenile chinook salmon (O. tshawytscha) and steelhead trout (Salmo gairdneri) move downstream from small tributaries to larger rivers to overwinter. Upstream movement of rearing coho has recently been shown by Skeesick (1970). Also, Goodnight and Bjornn (1971) found that young brook trout (S. fontinalis) left the main channel of Big Springs Creek in the winter and returned in the summer.

Our information suggests that rearing Dolly Varden and coho move upstream in the fall months and appear to concentrate in spring areas at the headwaters of Hood Bay Creek.

Temperatures taken during the winter showed that the headwaters of Hood Bay Creek were approximately 10°F warmer than the main stream area. This implies that the rearing fish moved upstream as the water temperature declined and actively sought the warmer spring-fed tributaries.

Gut analysis of rearing Dolly Varden and coho from the overwintering areas showed a significant decrease in the number of organisms eaten per fish and that only 60% of the population was feeding. Allen (1969b), Chapman and Bjornn (1969), and Hartman (1965) have shown that salmonid activity decreases with the temperature. Reimers (1957) and Hess and Rainwater (1939) have pointed out that the digestion rates of rearing fish decline at lower temperatures.

Lower activity levels and digestion rates at lower temperatures imply one reason why few Dolly Varden were caught in baited minnow traps. This suggests that the actual number of Dolly Varden using the overwintering areas is much higher than what we observed. We are unable to explain higher catches of coho relative to Dolly Varden. Perhaps coho are more tolerant of low temperatures, and being more active, would be attracted to minnow traps more readily. It is also possible that the coho were influenced by presmoltification, exhibiting an increase in activity (Hoar, 1958).

The food of rearing Dolly Varden and coho was found to come from three sources: eggs and fry of pink and chum salmon (O. gorbuscha and O. keta) and aquatic and terrestrial insects. We believe that insectan foods are the most important part of the young fish's diet during the rearing period by virtue of their

availability throughout the year and their presence in all areas of the creek inhabitable by rearing populations. The seasonal nature of salmon eggs and fry and their presence in limited areas of the creek indicate they may be of less importance than is usually assumed.

Rearing Dolly Varden consumed greater quantities of salmon eggs than coho. These eggs were probably released from the gravel by floods and redd building activities of adult salmon and since the young char attain greater size during their rearing period (Armstrong, 1970), they may be more capable of feeding on large items.

We found little evidence of cannibalism or predation of one rearing species upon the other. Young-of-the-year fry were usually found in very shallow areas, such as stream margins and small eddies and inlets, and apparently avoid predation until they are large enough to occupy swifter stream habitat.

Both rearing species extensively utilized most of the insect species in Hood Bay Creek with the exception of the rarer forms. Both species appear to show a preference for the most common aquatic insects. Nymphs of the genus Ephemerella and large species of Limnephilidae are seldom consumed probably due to complications involved with ingestion (Hartman, 1958).

The presence of relatively large proportions of surface insects, drifting Diptera pupae and exuviae indicates that coho rely primarily on drifting foods and surface insects. Drift feeding by coho has been conclusively shown by Demory (1961), Mason and Chapman (1965), Mundie (1969; 1971), and Peterson (1966).

Our information suggests that Dolly Varden also sample from the drift but to a lesser extent. We feel that the caseless Trichoptera larvae consumed by the young char, and most of the Ephemeroptera nymphs consumed were probably derived from the drift. The presence of large quantities of larval Chironomidae in Dolly Varden stomachs indicates they may be feeding on chironomids in excess of the chironomid standing crop. This suggests that the rearing char are exercising a certain amount of selection for chironomid larvae but whether these animals are captured from the substrate or drift is not known. Chironomid selection has been noted by Allen (1941a) in young Atlantic salmon (S. salar).

The significant difference between rearing Dolly Varden and coho diets lies in the amount of surface insects consumed by the two species. Allocthonous-autocthonous ratios indicate that coho consume a far greater percentage of surface insects than do Dolly Varden and consequently spend more time closer to the water surface. Fewer surface insects were consumed by rearing Dolly Varden which implies that they spend more time closer to the substrate.

This vertical distribution as exhibited by feeding habits appears to be established early in the life of the rearing species with the same trends of feeding found in both fry and fingerling of both species.

Studies of rearing Dolly Varden and coho at Hood Bay Creek have indicated that segregation exists between the two species.

Selective segregation has been demonstrated by Everest (1969) between steelhead and chinook as being substrate related and a function of disjunct emergence times. Chapman and Bjornn (1969) show that fish tend to occupy habitat with depth and velocity proportionate to body size.

We have noted that there are some basic differences in the habitat preferences of rearing Dolly Varden and coho. This may be regarded as selection segregation. Coho appear to prefer the slower waters (Ruggles, 1966) and in Hood Bay Creek were usually found in sloughs, backwaters, and small side tributaries. It is possible this is a function of their feeding behavior. Coho are active surface feeders whereas Dolly Varden prefer feeding closer to the bottom. Brett (1957) states that visual perception is important to feeding coho, and Mundie (1971) shows that coho are more likely to feed on surface food items even when subsurface drift is occurring and feels that items are more visible when on the surface. Habitats characterized by slow current, abundant terrestrial foods, and good visibility facilitate feeding for coho.

Dolly Varden appeared to prefer undercut banks as habitat. Perhaps this offers them necessary hiding areas from which they can venture out to collect drifting items and forage on the bottom.

Cut analysis has shown that coho in Hood Bay Creek feed extensively on the surface in all areas while Dolly Varden do so to a lesser extent. This suggests that vertical segregation occurs in communities of Dolly Varden and coho. Observations of fish in tank aquaria and in the stream showed that coho usually occupied areas closer to the surface while Dolly Varden were found nearer the substrate. Peterson (1966) and Fraser (1969) have noted that the same vertical distribution occurs between coho and steelhead.

Intraspecific aggression has been demonstrated for Dolly Varden by Newman (1960) and for coho (Chapman, 1962; 1966) and Mason and Chapman (1965). Interspecific conflicts resulting in segregation has been shown for many salmonids (Kalleberg, 1958; Hartman, 1965; Nilsson, 1965). Conflicts between Dolly Varden and coho may serve the function of establishing and maintaining vertical distribution in the char-coho community. In many instances a Dolly Varden becomes the dominant fish in a given area and it was noted that stomachs of many larger rearing char contained a greater proportion of surface insects than did those from smaller char. Despotism in Dolly Varden may function as a certain selective measure, assuring that many char will survive to reach smolt size. Since Dolly Varden smolts are usually larger than coho and spend more time in fresh water (Armstrong, 1970), they, like most salmonids, may need larger territories (Chapman, 1966). Therefore, assumption of a despotic role in the char-coho community would add a decisive survival benefit for the individual.

Nilsson (1965) examined allopatric and sympatric populations of Arctic char (S. alpinus) and brown trout (S. trutta) and found that their food demands are similar when alone, but change markedly under sympatric conditions. Segregation has been shown to occur between Dolly Varden and coho at Hood Bay Creek, which we feel is established and maintained by interspecific agnostic behavior and reflected by differences in feeding behavior and the type of food consumed. Palmisano (1971) has also indicated differences in food habits between rearing Dolly Varden and coho on Amchitka Island, Alaska.

Burns (1971) determined that intraspecific competition with a population is more influential than interspecific competition in determining a stream's carrying capacity. Fraser (1969) found that intermediate densities of juvenile steelhead and coho exhibited almost entirely intraspecific competition. Aggressive interaction between juvenile coho results in the emigration of surplus young-of-the-year fry (Chapman, 1962) allowing the carrying capacity to adjust with each year's recruitment of fry.

Experiments in artificial streams at Hood Bay indicate that the carrying capacity for Dolly Varden and coho communities may also be regulated more by intraspecific means, since approximately the same numbers of fish left the troughs when they were introduced alone and when introduced together.

Management Implications

Fish Stocking:

The establishment of segregated communities of rearing Dolly Varden and coho in Southeast Alaska streams may have significant management implications for fisheries management biologists. Juvenile steelhead, in particular, occupy positions close to the substrate when young coho are present (Fraser, 1969; Peterson, 1966). Our information shows that Dolly Varden also distribute themselves in a similar manner in the presence of coho. Introduction of hatchery steelhead juveniles into a stream containing natural char-coho communities may cause direct conflict between steelhead and Dolly Varden young. Mason and Chapman (1965) have demonstrated that the first coho young to emerge from the gravel occupy territories and assume "settlers rights" in that location, and defend it vigorously from intruders. The same may be true for Dolly Varden, particularly the larger despotic individuals. It is therefore plausible that introduced steelhead may come into direct conflict with established populations of rearing Dolly Varden and be driven into poor habitat or even excluded from the system as was demonstrated for coho by Chapman (1962).

Many systems in Southeast Alaska contain natural populations of rearing Dolly Varden, coho, steelhead, and cutthroat. These systems are usually characterized

by: (1) larger watersheds than those containing only Dolly Varden and coho; (2) having a greater variety of habitat types than streams occupied by char-coho communities. Hartman and Gill (1968) have shown that steelhead are usually found in rivers and smaller streams with steep gradients. Cutthroat were usually found in small streams with networks of sloughs, and where both species occur, cutthroat occupied the headwaters and small tributaries and steelhead the lower reaches of the mainstream.

Considering the above information, the management biologist should examine the nature and characteristics of the stream and determine if all habitat available is being used effectively by the natural populations. No efforts should be made to stock non-native fish in small watersheds lacking in habitat diversity and supporting strong char-coho communities.

Multispecies Management:

Systems capable of supporting numerous fish species should be managed as such. Since food habits of freshwater fish are very flexible (Larkin, 1966), interactive segregation between competing species allows maximum utilization of available habitat. Fraser (1969), Hartman (1965), and Nilsson (1965) contend that two or more species use habitat more efficiently than a single species, and Carlander (1955) states that total standing crop of fishes increases with the number of species or as niches are occupied. In fact, our information and that of Burns (1971) shows that intraspecific competition rather than conflict between species causes the greatest amount of fluctuation in population density.

Elimination of competing fish species in favor of another under the auspices of predator control may increase the standing crop of that species significantly (Carlander, 1955), but is incompatible with the biological aesthetic aspects involved. Systems that support numerous fish species have a greater total standing crop and increased aesthetic benefit to the angler who realizes that he has a variety of sporting fish to choose from.

CONCLUSIONS

1. Rearing Dolly Varden and coho appear to move upstream during the fall months and overwinter in warm spring-fed tributaries located in the headwaters of Hood Bay Creek.
2. Dolly Varden and coho are uniformly distributed throughout Hood Bay Creek. Rearing Dolly Varden appear to prefer undercut banks as habitat while coho prefer slow moving sloughs and side channels.

The fry of both species were usually found in shallow stream margins and tributaries. Dolly Varden distribution may be related to water velocity. Fry were found in slow moving areas, and the largest individuals found in riffles.

3. Dolly Varden fry seldom attack each other or coho fry. Coho fry are aggressive toward each other and toward char fry. Conversely, Dolly Varden fingerling usually become the dominant individuals in a community and attack other char and coho fingerling. Fingerling coho commonly attack each other, but few instances of aggression toward Dolly Varden of similar size occur.
4. Dolly Varden and coho population densities are more readily regulated by intraspecific competition than interspecific.
5. Insects appear to be the major food item in the diet of rearing Dolly Varden and coho. Salmon eggs and fry are included as food but only during specific periods of the season.
6. Interspecific competition appears to establish and maintain a vertical distribution in rearing Dolly Varden-coho communities. Food habits reflect this distribution with Dolly Varden stomachs containing more foods derived from the benthic fauna and coho consuming more drifting and surface food items.
7. Food habits of rearing Dolly Varden and coho do not appear to change significantly as growth is attained but it was observed that larger individuals can consume larger food items and that dominant char tend to consume more surface insects.
8. Fewer Dolly Varden feed during the winter than do coho. Coho may be more tolerant to low temperatures or the fish examined were pre-smolts.
9. Both species of rearing fish utilize insect drift for food, coho much more often than Dolly Varden.
10. Dolly Varden may be selectively feeding on Chironomidae larvae.

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